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(19) (CA) **CANADIAN PATENT** (12)

(54) Pipeline Conditioning Process for Mined Oil-Sand

(72) Cymerman, George J. , Canada  
Leung, Antony H. S. , Canada  
Maciejewski, Waldemar B. , Canada

(73) Same as inventor

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"PIPELINE CONDITIONING PROCESS FOR MINED OIL-SAND"

ABSTRACT OF THE DISCLOSURE

As-mined, naturally water-wet oil sand is mixed at the mine site with hot water, air and NaOH to produce a slurry. The slurry is pumped through a pipeline at least about 2.5 kilometres in length and is fed directly to a conventional gravity separation vessel. In the course of being pumped through the pipeline, sufficient coalescence and aeration of bitumen occurs so that, when subsequently retained in the vessel under quiescent conditions, a desirable amount of the bitumen floats, forms froth, and is recovered.

FIELD OF THE INVENTION

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This invention relates to simultaneously transporting and conditioning oil sand in an aqueous slurry in a pipeline extending between a mine and an extraction plant. More particularly, it relates to a process comprising the steps of surface mining naturally water-wet oil sand, mixing the as-mined oil sand, with heated water, air and (optionally) process aid (e.g. NaOH) at the mine site to form an aerated slurry, pumping the resultant slurry through the pipeline a sufficient distance so that contained bitumen flecks separate from sand, coalesce and are aerated, and feeding the slurry directly into a gravity separation vessel to recover the major portion of the bitumen as primary froth.

BACKGROUND OF THE INVENTION

The present invention is a modification of the conventional commercial system used to extract bitumen from mineable oil sand. In order to understand the manner in which the invention departs from this conventional system and to appreciate the discoveries on which the invention is based, it is first useful to describe the conventional system.

As previously stated, the invention has to do with oil sand, specifically the oils and of the Athabasca deposit which exists in Northern Alberta. This oil sand comprises sand grains that are water-wet or individually coated with a thin sheath of water. The bitumen or oil is present as flecks located in the interstices between the wet rains.

At applicants' plant, the deposit is surface mined by first removing overburden and then using a dragline to excavate the oil sand and dump it to one side in the form of a windrow.



1 A bucket wheel reclaimer transfers this windrowed oil sand on to  
2 the feed end of a conveyor belt train, which carries it to an  
3 extraction plant.

4 Applicant's operation involves mining about 300,000  
5 tons of oil sand per day in this way. Four draglines are  
6 employed, each feeding a separate reclaimer and conveyor belt  
7 train.

8 Each such conveyor belt train comprises a plurality of  
9 separate endless conveyors placed end to end in series. The  
10 conveyors of one train typically can extend a length of 5  
11 miles.

12 The conveyor system being utilized is characterized by  
13 a number of disadvantages, including:

- 14 - That each conveyor consumes a large amount of  
15 electric power. A 72 inch wide conveyor having  
16 a length of 3 miles requires several 1200  
17 horsepower motors for operation;
- 18 - That the conveyor train has to turn corners, which  
19 is a difficult and expensive operation requiring  
20 use of a multiplicity of short straight conveyors;
- 21 - That the tacky bitumen causes some oil sand to  
22 adhere to and build up on the belt surface. This  
23 creates a dead load which is difficult to prevent  
24 and remove; and
- 25 - That the conveyors are subjected to heavy wear in  
26 this service, due to impacts by rocks in the oil  
27 sand and the erosive nature of the sand.

1           In summary, the conveyor systems used are a troublesome and  
2 expensive means for transferring the oil sand from the mine to the  
3 extraction plant.

4           It will also be noted that a conveyor system transports the  
5 whole oil sand to the plant, for the sole purpose of extracting the  
6 bitumen, which constitutes only about 6-15% by weight of the oil sand  
7 mass. Conveying all of the associated gangue material significantly  
8 reduces the economic attractiveness of the operation.

9           Once the oil sand arrives at assignees' bitumen extraction  
10 plant, it is fed into one of four extraction circuits, each of which  
11 begins with a tumbler. These tumblers are large, horizontal, rotating  
12 drums. In the drum, the oil sand is mixed with hot water and a small  
13 amount of process aid, normally sodium hydroxide. Steam is sparged into  
14 the formed slurry as it proceeds down the length of the slightly  
15 inclined drum. In greater detail, each drum is 30.5 m long and 5.5 m  
16 in diameter. Each such drum is fed about 4500 tph of oil sand, 1100  
17 tph of hot water (95°C) and 5 tph of aqueous 10% caustic solution.  
18 Steam is injected into the slurry, as required, to ensure a final  
19 slurry temperature of about 80°C. The retention time in the drum is  
20 about 3 minutes.

21           The process in the tumbler seeks to attain several ends,  
22 namely:

- 23           - heating the viscous bitumen, to reduce its viscosity  
24           and render it more amenable to separation from the  
25           sand grains;
- 26           - dispersing the heated bitumen from the solids and into  
27           the water;

- 1           -     ablating or disintegrating the normally present
- 2                   lumps of oil sand, so that they will not be lost
- 3                   with oversize rocks in a screening step which
- 4                   immediately follows tumbling;
- 5           -     entraining air bubbles in the slurry;
- 6           -     coalescing some small bitumen flecks into larger
- 7                   flecks to make them amenable to aeration and
- 8                   subsequent separation; and
- 9           -     aerating bitumen flecks by contacting them with air
- 10                   bubbles, whereby the bitumen coats the air bubbles.

11           The expression, used in the industry to identify the sum  
12 total of these various actions, is "conditioning" the slurry. A  
13 definition is given below with respect to when conditioning is  
14 "complete" for the purposes of this invention.

15           After being partly conditioned in the tumbler, the slurry  
16 is screened, to reject oversize, and simultaneously diluted with  
17 additional hot water to produce a slurry having about 50% solids by  
18 mass (based on the initial oil sand feed).

19           The screened, diluted slurry is fed into a large,  
20 thickener-like vessel referred to as a gravity separation vessel or  
21 primary separation vessel (or "PSV"). The vessel is open-topped,  
22 having a cylindrical upper section and a conical lower section  
23 equipped with a bottom outlet. The diluted slurry is temporarily  
24 retained in the PSV for about 15 minutes in a quiescent state. The  
25 coarse solids sink (having a density of about 2.65), concentrate in  
26 the cone, and exit through the bottom outlet as a fairly dense  
27 tailings stream. The non-aerated bitumen flecks have a density of  
28 about 1.0 and thus have little natural tendency to rise. However,  
29 the bitumen has an affinity for air. Because of this property,  
30 some of the non-aerated bitumen flecks form films around the air  
31 bubbles present in the slurry and join with the aerated bitumen  
32 created in the tumbler in rising to form bitumen froth at the

1 surface of the slurry. This froth overflows the upper lip of the  
2 vessel into a launder and is recovered. The froth recovered in this  
3 manner is referred to as "primary bitumen froth". The process  
4 conducted in the PSV may be referred to as involving "spontaneous  
5 flotation".

6 The watery suspension remaining in the central portion of  
7 the PSV contains some residual bitumen. Much of this bitumen was not  
8 sufficiently aerated so as to be recovered as primary froth from the  
9 PSV. Therefore it is necessary to further process this fluid to  
10 recover the remaining bitumen. This is done by means of vigorously  
11 sub-aerating and agitating the fluid in one or more secondary recovery  
12 vessels. For example, a dragstream of the middlings from the PSV may  
13 be fed to a series of sub-aerated flotation cells. A yield of bitumen  
14 froth, termed secondary froth, is recovered. Flotation in the PSV may  
15 be referred to as "spontaneous flotation" while flotation in the  
16 secondary recovery vessel may be referred to as "forced air flotation".

17 The combination of the PSV and the subsequent secondary  
18 recovery means is referred to herein as the "separation circuit".

19 The primary bitumen froth is formed under quiescent  
20 condition and hence has less entrainment of gangue material. Thus it  
21 is considerably "cleaner" than secondary froth, in that it contains  
22 less water and solid contaminants. So it is desirable to maximize  
23 production of the bitumen in the form of primary froth.

24 If conditioning has been properly accomplished, the  
25 following desirable results are achieved:

- 26 - the total recovery of bitumen obtained, in the form of
- 27 the sum of primary and secondary froth, is high;
- 28 - the loss of bitumen with the tailings is low; and
- 29 - the bitumen is predominantly recovered in the form of
- 30 primary froth.

1           At this point it is appropriate to make the point that  
2 the nature of the oil sand being processed has a marked influence  
3 on the results that are obtained. If the oil sand is of "good"  
4 grade (i.e. high in bitumen content - e.g. 13.2% by weight - and  
5 low in -325 mesh solids - e.g. 15% by weight) it will process well,  
6 giving:

- 7           - a high total bitumen recovery (e.g. 95%); and
- 8           - low bitumen losses with the tailings (e.g. 3%).

9 If the oil sand is of "poor" grade (i.e. low in bitumen content  
10 (e.g. 8%) and high in fines content (e.g. 30%)), it will process  
11 relatively poorly, giving:

- 12           - a low total bitumen recovery (e.g. 85%); and
- 13           - high bitumen losses with the tailings (e.g. 12%).

14           In summary then, the conventional extraction circuit  
15 comprises a tumbling step designed to condition the slurry.  
16 Tumbling is followed by a sequence of spontaneous and forced air  
17 flotation steps. If conditioning is properly conducted, the total  
18 bitumen recovery and bitumen loss values for different grades of  
19 feed will approximate those illustrative values just given.

20           Now, it has long been commonly known that particulate  
21 solids may be slurried in water and conveyed by pumping them  
22 through a pipeline, as an alternative to using conveyor belt  
23 systems.

24           However, to the best of our knowledge the public prior  
25 art is silent on whether oil sands can successfully be conveyed in  
26 this fashion, as part of an integrated recovery process. More  
27 particularly, the literature does not teach what would occur in  
28 such an operation.



1           The present invention arose from an experimental project  
2 directed toward investigating pipeline conveying of oil sands in  
3 aqueous slurry form.

4           The project was carried out because it was hoped that  
5 pipelining a slurry of oil sand might prove to be an economically  
6 viable substitute for the conveyor belt plus tumbler system previously  
7 used to feed the separation circuit. There were questions that needed  
8 to be answered to establish this viability. The answers to these  
9 questions were not predictable. More particularly, it was questionable  
10 whether:

- 11       -     sufficient bitumen in the oils and slurry would become  
12             properly aerated in a pipeline so as to yield:
  - 13                 -     a high total bitumen recovery, and
  - 14                 -     a high primary oil froth recovery; or
- 15       -     the bitumen would become excessively emulsified in the  
16             course of being pumped several miles through a pipeline, so  
17             that the bitumen would become difficult to recovery from  
18             the slurry.

#### 19                               SUMMARY OF THE INVENTION

20           This invention relates to simultaneously transporting and  
21 conditioning oil sand in an aqueous slurry in a pipeline extending  
22 between a mine and an extraction plant. More particularly, it relates  
23 to a process comprising the steps of surface mining naturally water-wet  
24 oil sand, mixing the as-mined oil sand, with heated water, air and  
25 (optionally) process aid (e.g. NaOH) at the mine site to form an  
26 aerated slurry, pumping the resultant slurry through the pipeline a  
27 sufficient distance so that contained bitumen flecks separate from  
28 sand, coalesce and are aerated, and feeding the slurry directly into  
29 a gravity separation vessel to recover the major portion of the bitumen  
30 as primary froth.

1           The present invention is based on having made certain  
2 experimental discoveries, namely:

- 3       -     That if a slurry, comprising oil sand, heated water and process  
4 aid, is formed so as to entrain air bubbles and is pumped through  
5 a pipeline a distance in the order of about 2.5 km (which is  
6 commonly less than the distance between the surface mine and  
7 the extraction plant), complete conditioning of the slurry is  
8 achieved.     More particularly, a sufficient quantity of  
9 the contained bitumen becomes aerated and is rendered  
10 buoyant. As a result, the slurry may be introduced directly

1 into the PSV of a conventional separation circuit,  
2 in which PSV spontaneous bitumen flotation takes  
3 place to yield total recovery, underflow loss, and  
4 froth quality values that are comparable to those  
5 obtained by a conventional extraction train  
6 involving a tumbler and separation circuit;

7 - That the slurry may be at a relatively low  
8 temperature (e.g. in the order of 50°C) and yet  
9 conditioning may still be successfully completed  
10 as aforesaid;

11 - That there is a "conditioning breakover point"  
12 for a particular slurry during the course of  
13 passage through a particular pipeline. More  
14 particularly, with increasing retention time up  
15 to the breakover point, there is:

- 16 - an increase in subsequent total bitumen
- 17 recovery from the separation circuit, and
- 18 - a diminishment in subsequent losses of
- 19 bitumen with the underflow tailings from the
- 20 separation circuit.

21 The breakover point indicates when conditioning  
22 is "complete". Such complete conditioning of the  
23 slurry is reflected in the total recovery and  
24 tailings loss values resulting from subsequent  
25 processing of the slurry in a conventional  
26 separation circuit. More particularly, the total  
27 recovery of bitumen will exceed 90% by weight and  
28 the tailings loss of bitumen will be less than  
29 10%, with respect to a feed of sufficient quality

1 to be acceptable for a conventional extraction  
2 circuit;

3 - That if the slurry is pumped further through the  
4 pipeline after conditioning is complete, significant  
5 emulsification does not occur. Stated otherwise, the  
6 total recovery and tailings loss values remain  
7 generally constant, even though retention time in the  
8 pipeline far exceeds that required for complete  
9 conditioning; and

10 - That if the completely conditioned slurry is subjected  
11 to separation of the coarse solids (as by settling)  
12 part way along its passage through the pipeline, it is  
13 found that the solids will readily separate in a  
14 substantially clean condition. Stated otherwise, once  
15 completely conditioned, passage of the slurry through  
16 the pipeline may be interrupted and the coarse solids  
17 may be separated and discarded without appreciable  
18 bitumen loss. The remaining slurry may then be pumped  
19 through the pipeline the remainder of the distance to  
20 the extraction plant.

21 Having ascertained these unpredictable discoveries,  
22 applicants conceived the following process:

23 As an optional preferred first step, oil sand oversize is  
24 removed, by crushing or screening, prior to mixing, to reduce lumps to  
25 a size less than about 1/3 of the internal diameter of the pipeline.  
26 If the lumps are too large, plugging of the line can ensue.

27 The oil sand is heated at the mine site with heated water  
28 (typically at 95°C) and, preferably, alkaline process aid (usually  
29 sodium hydroxide), in a manner whereby air bubbles are entrained, to  
30 form an aerated slurry having a composition and temperature falling  
31 within the following preferred ranges:

1	<u>Component</u>	<u>% by weight</u>
2	oil sand	50 - 70
3	water	50 - 30
4	process aid	0.00 - 0.05
5	slurry temperature (°C)	40 - 70

6           The slurry is then preferably screened, to remove residual  
7   oversize, and pumped through a pipeline from the mine site toward an  
8   extraction plant. The pipeline must be of sufficient length so that  
9   substantially complete conditioning of the oil sand occurs.  
10   Preferably, the slurry is moved through a first section of the  
11   pipeline, in which substantially complete conditioning is accomplished,  
12   and then separation of substantially all of the coarse solids (i.e.  
13   greater than 200 mesh) is effected at this point. This may be  
14   accomplished by gravity as in a settler or enhanced settling, such as  
15   with cyclones. Depending on the density of the slurry, dilution with  
16   water may be required for good separation. The remaining slurry is  
17   then pumped through a second section of the pipeline to the extraction  
18   plant. On reaching the extraction plant, the slurry is introduced  
19   directly into a conventional separation circuit comprising spontaneous  
20   and forced air flotation units. By "directly" is meant that the slurry  
21   is not processed in a tumbler on its way to the gravity separator or  
22   PSV. It is found that the total recovery of bitumen from the  
23   separation circuit exceeds 90% of that contained in the oil sand feed  
24   and the tailings losses are less than 10%.

25           Broadly stated, the invention is a process for  
26   simultaneously transporting and conditioning naturally water-wet oil  
27   sand containing bitumen, to enable recovery of bitumen in a gravity  
28   separation vessel forming part of a bitumen extraction plant,  
29   comprising: surface mining oil sand at a mine site; mixing the oil  
30   sand, at the mine site, with heated water and entraining air in the  
31   mixture during mixing, to form an aerated slurry; pumping the slurry

1 through a pipeline from the mine site to the extraction plant, said  
2 pipeline being of sufficient length so that separation of bitumen from  
3 sand and subsequent aeration of bitumen both occur, to render the  
4 aerated bitumen buoyant; and introducing the slurry from the pipeline  
5 directly into the gravity separation vessel and processing it therein  
6 by gravity separation under quiescent conditions to recover bitumen in  
7 the form of froth.

#### 8 DESCRIPTION OF THE DRAWINGS

9 Figure 1 is a schematic of the laboratory circuit used in  
10 connection with development of the invention;

11 Figure 2 is a plot showing bitumen recovery variation with  
12 distance pipelined, for a 13.2% bitumen-containing oil sand treated in  
13 the laboratory circuit of Figure 1;

14 Figure 3 is a plot showing bitumen recovery variation with  
15 distance pipelined, for a 9.2% bitumen-containing oil sand treated in  
16 the laboratory circuit of Figure 1;

17 Figure 4 is a plot showing the variation in bitumen lost  
18 with the tails with distance pipelined for a 9.2 bitumen-containing oil  
19 sand treated in the laboratory circuit of Figure 1;

20 Figure 5 is a plot showing the variation in percent of  
21 bitumen not amenable to flotation with distance pipelined for a 9.2%  
22 bitumen-containing oil sand treated in the laboratory circuit of Figure  
23 1;

24 Figure 6 is a plot showing the variation in total bitumen  
25 recovery with distance pipelined for a 9.2% bitumen-containing oil sand  
26 treated in the laboratory circuit of Figure 1; and

Figure 7 is a schematic of an industrial scale system for practising the process.

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### DESCRIPTION OF THE PREFERRED EMBODIMENT

Experimental work was conducted that led to the process discoveries previously referred to.

More particularly, a pilot pipeline loop 1, schematically shown in Figure 1, was used. The loop 1 was 230 feet long and had an internal diameter of 2 inches. The loop 1 was connected with a pump box 2. Oil sand could be fed to the pump box 2 by a conveyor 3. A positive displacement pump 4 was connected to the bottom outlet of the box 2. Slurry could be re-circulated back into the pump box 2 from the initial section of the loop 1 via a pipe leg 5. Valves 6,7 controlled the leg 5 and loop 1 (downstream of the leg 5) respectively. In operation, the pump box 2 would be filled with an amount of water in excess over that required to fill loop 1. Valve 6 would be opened and valve 7 closed. Oil sand would then be fed into the pump box 2 and the mixture circulated through the box 2 tangentially to entrain air and form an aerated slurry. In some runs, sodium hydroxide, in the form of a 10% solution, was added at the pump box; in other runs, no sodium hydroxide was added. Recirculation was continued for 30 seconds, to form the slurry. After such circulation, the valve 7 was opened and the valve 6 closed, so that the full loop 1 was now in use. Circulation through the full loop would then be continued for the retention time required to establish the pipeline distance to be travelled by the slurry. In a typical run, 105 kg of oil sand

1 were added to 42 kg of hot water (having a temperature of 90°C),  
2 to yield a slurry having a temperature of 50°C. Samples of the  
3 slurry were periodically withdrawn through the valve 8 at the  
4 outlet from the box 2. The pump speed was adjusted to provide  
5 a slurry velocity of 8 feet/second.

6 It is to be noted that the slurry water content (30-  
7 50%) was higher than that in the slurry processed in a  
8 conventional tumbler (18-25%).

9 To compare the conditioning accomplished in the  
10 pipeline with that of the conventional tumbler circuit, slurry  
11 withdrawn from the loop 1 was tested in a laboratory scale  
12 separation circuit. More particularly, withdrawn samples were  
13 treated as follows:

- 14 - A slurry sample of 300 mL was collected in a 1L  
15 jar already containing 300 mL of water having a  
16 temperature of 50°C (so that the resultant mixture  
17 now corresponded in water content with that of the  
18 diluted slurry conventionally fed to a primary  
19 separation vessel), and stirred;
- 20 - The diluted sample was settled for 1 minute under  
21 quiescent conditions, to allow froth to rise by  
22 spontaneous flotation and solids to settle;
- 23 - The froth (which was the "primary" froth) was  
24 skimmed off and analyzed for bitumen, water and  
25 solids;
- 26 - The aqueous layer was decanted off and saved;
- 27 - The coarse solids were washed with 150 ml of 50°C  
28 water by capping the jar and rotating it gently  
29 5 times. After settling for 1 minute, the aqueous



phase was decanted and saved. This washing procedure was repeated twice more;

- The washed solids were analyzed for oil, water and solids;
- The water decant fractions were combined. The product was subjected to induced air flotation at an impeller speed of 800 rpm and air rate of 50 mL/minute. The temperature of the charge was maintained at 50°C and air addition was continued for 5 minutes. Secondary froth was produced and collected. This secondary froth and the residual tailings were analyzed for bitumen, water and solids.

The analytical methods used to determine the oil, water and solids contents were those set forth in "Syncrude Analytical Methods for Oil Sand and Bitumen Processing", published by The Alberta Oil Sands Technology and Research Authority (1979).

The previously described laboratory scale process has been used many times in the past by assignee's research group and the results obtained have been shown to closely correspond with those from the separation circuit in the commercial plant of the assignees of this invention.

The various bitumen fractions were established using the following relationships:

$$\% \text{ primary recovery} = \frac{\text{bitumen in primary froth}}{\text{total bitumen in feed}} \times 100\%$$

$$\% \text{ total recovery} = \frac{\text{bitumen in primary and secondary froths}}{\text{total bitumen in feed}} \times 100\%$$

1       % bitumen lost to coarse tailings =  
 2                               
$$\frac{\text{bitumen in coarse solids}}{\text{total solids in slurry}} \times 100\%$$
  
 3                               
$$\frac{\text{bitumen in oil sand}}{\text{total solids in oil sand}}$$
  
 4                                 
 5       % bitumen not amenable to flotation =  
 6                               
$$\frac{\text{bitumen in secondary tailings}}{\text{total solids in slurry}} \times 100\%$$
  
 7                               
$$\frac{\text{bitumen in oil sand}}{\text{total solids in oil sand}}$$
  
 8                                 
 9       Distance pipelined (km) = elapsed time from start of run  
 10                               x pipeline velocity

13       Two oil sands were used in the tests, as follows:

14               Ore "A" - "good" grade -       13.2% bitumen  
 15   15.0% fines  
 16               Ore "B" - "poor" grade -       9.2% bitumen  
 17   28.0% fines

18               Having reference to Figure 2, it will be noted that,  
 19       at a distance pipelined of about 2.5 - 3 km, the following  
 20       results occurred for runs using a good grade oil sand:

21       Dec. 9 runs:

22               Total bitumen recovery                       97%  
 23               Primary froth recovery                       96%

24       Jan. 12 runs:

25               Total bitumen recovery                       95%  
 26               Primary froth recovery                       92%

27               The recovery and losses reached fixed values and  
 28       remained virtually constant after the breakover point.

1            Having reference to Figure 3, at a distance pipelined  
2    of about 3 km (i.e. the breakover point) the following results  
3    occurred for a poor grade oil sand with the optimum amount of  
4    sodium hydroxide (0.05 wt%):

5            Total bitumen recovery	93%
6            Primary froth recovery	72%

7    The same group of runs also show:

8            Bitumen lost with primary tailings	2%
9            Bitumen that remained with	
10           secondary tailings	5%

11   Plots of oil losses to primary tailings, and oil remaining in  
12   secondary tailings are given in Figures 4 and 5 respectively.

13           The following conclusions are apparent from the data,  
14   namely:

- 15           -    That pipelining an oil sand slurry beyond the  
16           point where conditioning is complete does not  
17           over-condition the slurry;
- 18           -    That conditioning is complete within a short  
19           distance travelled, said distance being  
20           substantially less than the distance between the  
21           mine and the plant (for most of the plant life in  
22           a typical case);
- 23           -    That pipelining slurry will produce primary and  
24           total bitumen recoveries as good as or better than  
25           those from a conventional tumbler/flotation train;

- 1           -     That, following completion of conditioning, the
- 2                 coarse solids may be separated without prohibitive
- 3                 bitumen losses;
- 4           -     That a slurry conditioned in a pipeline can be
- 5                 fed directly to a separation circuit and the
- 6                 bitumen recoveries and losses will be found to be
- 7                 comparable to those obtained with a slurry
- 8                 conditioned in a tumbler; and
- 9           -     That process aids are required for low grade oil
- 10                sand to achieve good recoveries.

11           A minor amount of light hydrocarbon added at the  
12 slurry-formation stage serves to constantly clean the surface of  
13 the bitumen where it interfaces with the water. By having a  
14 clean surface, the bitumen globules more readily coalesce, which  
15 leads to better separation. Attachment of bitumen to air is also  
16 encouraged, which leads to improved subsequent flotation. The  
17 hydrocarbon should be liquid at room temperature. It is best  
18 added to the process as an emulsion in water. A concentration  
19 of about 5% hydrocarbon is suitable. Cheap and readily available  
20 hydrocarbons such as kerosene and naphtha may be used. Because  
21 they are taken up in the bitumen, they are not lost but form part  
22 of the upgraded synthetic crude product. The improvement  
23 manifests itself as an improvement in primary recovery, and is  
24 demonstrated in Figure 6.

25           Turning now to Figure 7, there is schematically shown  
26 a recommended system for practising the invention.

27           More particularly, oil sand is surface mined and  
28 deposited in a feed bin. The oil sand is then fed to a crusher  
29 55 of the double roll type, to reduce the oversize to less than

24". The crushed oil sand is fed by conveyor 56 to a mixer 57. This mixer 57 is shown in Figure 7. It comprises an open-topped cylindrical vessel 58 having a conical bottom 59 with a central outlet 60. The vessel 58 thus has a circular cross-section. A pair of tangential inlets 61, 62 extend into the base of the vessel chamber 58. Fresh hot water, containing caustic, is fed into chamber 58 via the inlet 61. Recycled hot slurry is fed in via inlet 62. The oil sand is mixed with recycled slurry, water and caustic, which are circulating in the form of a vortex in the chamber 58, and air bubbles are entrained in the slurry. The hot water and caustic additions are controlled to yield a slurry typically having the following values:

water content -	35%
NaOH content -	0.01%
temperature -	55°C

The product slurry leaves the chamber 58 through the bottom outlet 60, passes through a screen 63 that removes oversize and enters a pump box 64. The recycled slurry is withdrawn from pump box 64 and returned by pump 65 and line 66 to the inlet 62. Slurry is pumped by pump 67 from pump box 64 into pipeline 68. The slurry is conveyed through a first section of pipeline 68, far enough to completely condition the slurry. The extent of conditioning may be established using laboratory equipment and procedures as previously described. At this point, the slurry is diluted and introduced into a settler 69 and retained under quiescent conditions, to allow the coarse solids to settle. The solids are removed as tailings and discarded. In this manner, 60 to 70% of the total mass of slurry is eliminated. The remaining slurry is pumped through a second section 70 of pipeline to a conventional separation circuit 71. Here the slurry is subjected to spontaneous flotation in a primary separation vessel 72 and middlings from the vessel 72 are subjected to forced air flotation in cells 73 to produce primary and secondary froth respectively.

1           As has been previously pointed out, the step of removing  
2 coarse solids from the slurry part way along its travel through the  
3 pipeline is an optional step. Alternatively, one may elect to pump the  
4 slurry, containing the coarse solids, directly from the pump box 64,  
5 through the pipeline 68, to the separation vessel 72.

6           It will be noted that the slurry temperature (55°C) is  
7 considerably less than the conventional temperature (=80°C). If a  
8 tumbler were to be used with such a "low temperature" slurry, it would  
9 have to be very large, to provide a longer retention time. By the  
10 combination of conditioning in a pipeline and feeding conditioned  
11 slurry directly to the PSV, a low temperature process is now feasible,  
12 without the need for a very large tumbler.

13           The scope of the invention is set forth in the claims now  
14 following.

1 THE EMBODIMENTS OF THE INVENTION IN WHICH AN EXCLUSIVE  
2 PROPERTY OR PRIVILEGE IS CLAIMED ARE DEFINED AS FOLLOWS:

3 1. A process for simultaneously transporting and  
4 conditioning naturally water-wet oil sand containing bitumen, to enable  
5 recovery of bitumen in a gravity separation vessel forming part of a  
6 bitumen extraction plant, comprising:

7 surface mining oil sand at a mine site;  
8 mixing the oil sand, at the mine site, with heated water and  
9 entraining air in the mixture during mixing, to form an aerated slurry;  
10 pumping the slurry through a pipeline from the mine site to  
11 the extraction plant, said pipeline being of sufficient length so that  
12 separation of bitumen from sand and subsequent aeration of bitumen both  
13 occur, to render the aerated bitumen buoyant; and

14 introducing the slurry from the pipeline directly into the  
15 gravity separation vessel and processing it therein by gravity  
16 separation under quiescent conditions to recover bitumen in the form  
17 of froth.

18 2. The process as set forth in claim 1 comprising;  
19 introducing process aid to the aerated slurry during mixing.

20 3. The process as set forth in claim 1 comprising;  
21 screening oversize from the aerated slurry following mixing  
22 so that it can be pumped through the pipeline.

23 4. The process as set forth in claim 3 comprising;  
24 introducing process aid to the aerated slurry during mixing.

25 5. The process as set forth in claim 1, 2, 3 or 4 wherein:  
26 the pipeline is at least 2.5 kilometers in length.

6. The process as set forth in claim 4 wherein:

mixing is conducted so as to form a slurry containing, by weight, about 50 to 70% oil sand, about 50 to 30% water and less than about 0.05% alkaline process aid, said water being supplied at a temperature sufficient to yield a slurry having a temperature in the range of about 40 - 70°C.

7. The process as set forth in claim 6 wherein:

the pipeline is at least 2.5 kilometers in length.

8. The process as set forth in claim 1, 2, 3 or 4

comprising:

crushing the as-mined oil sand prior to mixing to reduce lumps in size.

9. The process as set forth in claim 7 comprising:

crushing the as-mined oil sand prior to mixing to reduce lumps in size.

10. The process of claim 1 or 7 wherein:

the mixing and entraining step is accomplished by adding the oil sand to a slurry vortex circulating in a vessel of circular cross-section and removing aerated slurry from the base of the vessel for introduction into the pipeline.



1            11.     A process for simultaneously transporting and  
2     conditioning naturally water-wet oil sand containing bitumen, to enable  
3     recovery of bitumen in a gravity separation vessel forming part of a  
4     bitumen extraction plant, comprising:

5            surface mining oil sand at a mine site;  
6            mixing the oil sand, at the mine site, with heated water and  
7     entraining air in the mixture during mixing, to form an aerated slurry;  
8            pumping the slurry through a first section of pipeline a  
9     sufficient distance so that separation of bitumen from sand and  
10    subsequent aeration of bitumen both occur, to render the aerated  
11    bitumen buoyant;

12           separating a major portion of the sand from the slurry;  
13           pumping the remaining slurry through a second section of  
14    pipeline extending to a bitumen extraction plant; and

15           introducing the remaining slurry from the pipeline directly  
16    into the gravity separation vessel and processing it therein by gravity  
17    separation under quiescent conditions to recovery bitumen in the form  
18    of froth.

19           12.     The process as set forth in claim 11 comprising;  
20           introducing process aid to the aerated slurry during mixing.

21           13.     The process as set forth in claim 11 comprising;  
22           screening oversize from the aerated slurry following mixing  
23    so that it can be pumped through the pipeline.

24           14.     The process as set forth in claim 13 comprising;  
25           introducing process aid to the aerated slurry during mixing.

1                   15. The process as set forth in claim 11, 12, 13 or 14  
2    wherein:  
3                   the pipeline is at least 2.5 kilometers in length.

4                   16. The process as set forth in claim 14 wherein:  
5                   mixing is conducted so as to form a slurry containing, by  
6    weight, about 50 to 70% oil sand, about 50 to 30% water and less than  
7    about 0.05% alkaline process aid, said water being supplied at a  
8    temperature sufficient to yield a slurry having a temperature in the  
9    range of about 40 - 70°C.

10                  17. The process as set forth in claim 16 wherein:  
11                  the pipeline is at least 2.5 kilometers in length.

12                  18. The process as set forth in claim 11, 12, 13 or 14  
13    comprising:  
14                  crushing the as-mined oil sand prior to mixing to reduce  
15    lumps in size.

16                  19. The process as set forth in claim 17 comprising:  
17                  crushing the as-mined oil sand prior to mixing to reduce  
18    lumps in size.

19                  20. The process of claim 11 or 17 wherein:  
20                  the mixing and entraining step is accomplished by adding the  
21    oil sand to a slurry vortex circulating in a vessel of circular cross-  
22    section and removing aerated slurry from the base of the vessel for  
23    introduction into the pipeline.



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*E P Johnson*

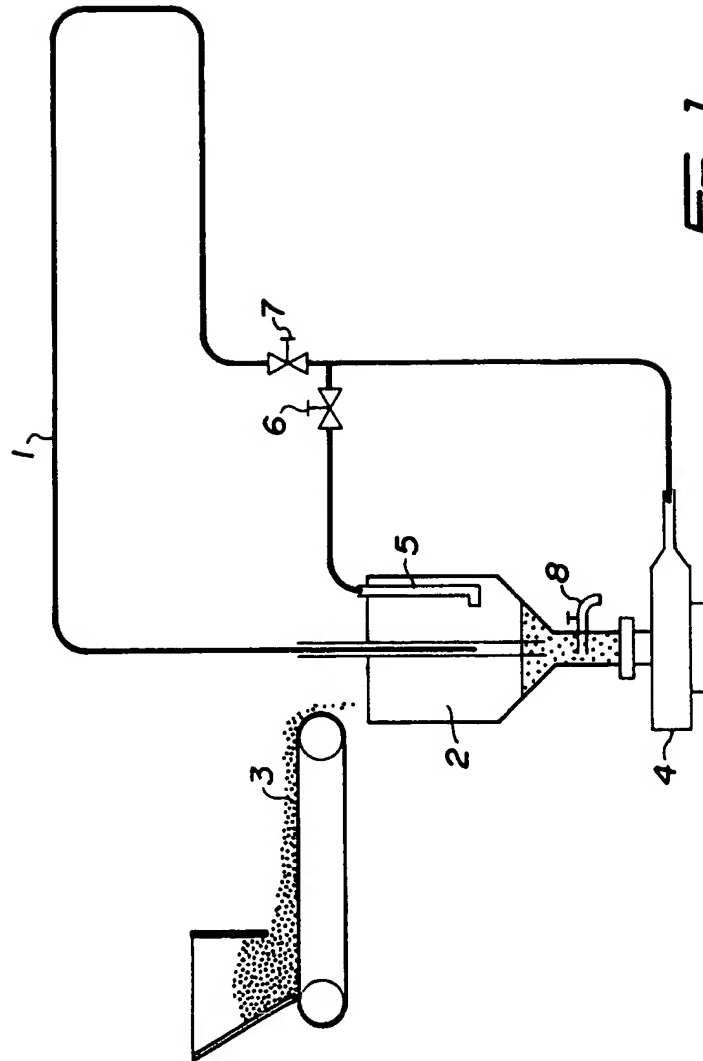


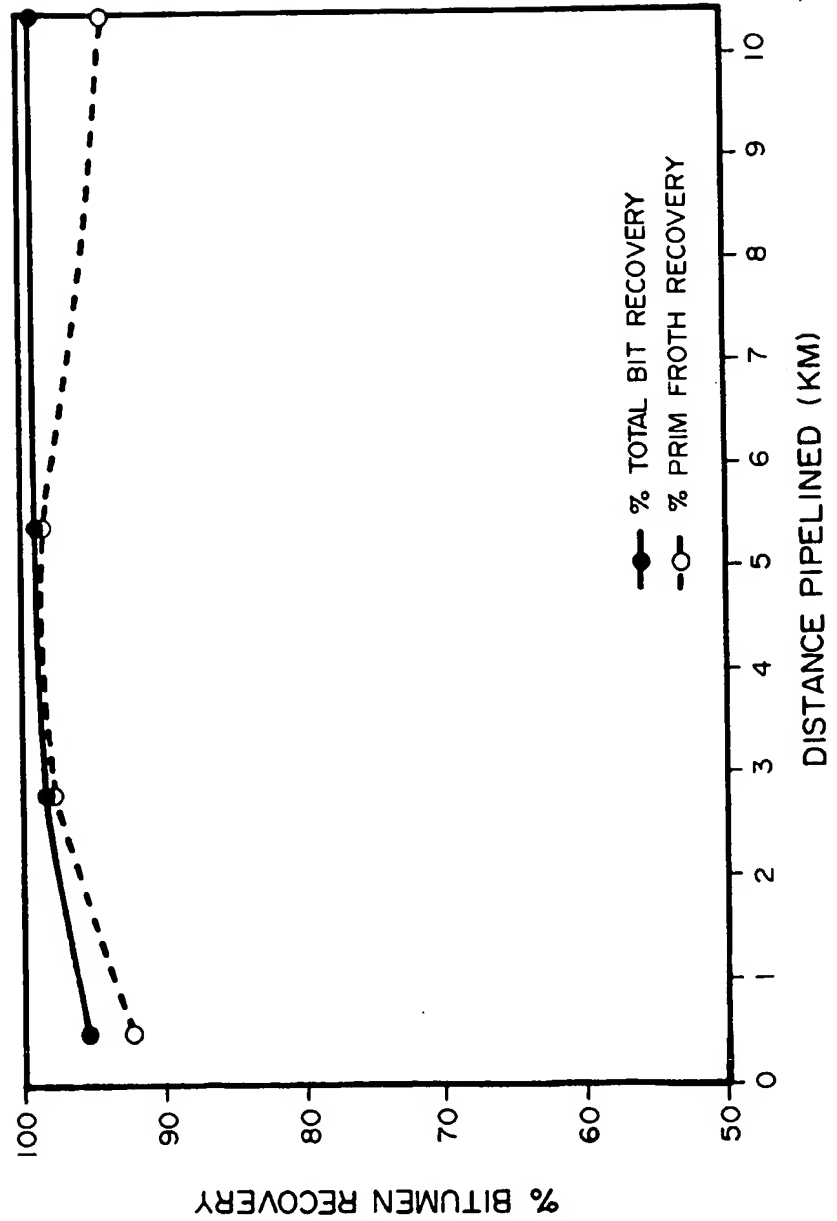
Fig. 1.

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Fig. 2.

% BITUMEN RECOVERY vs DISTANCE PIPELINED (KM)

FOR A 13.2 % BITUMEN OIL SAND



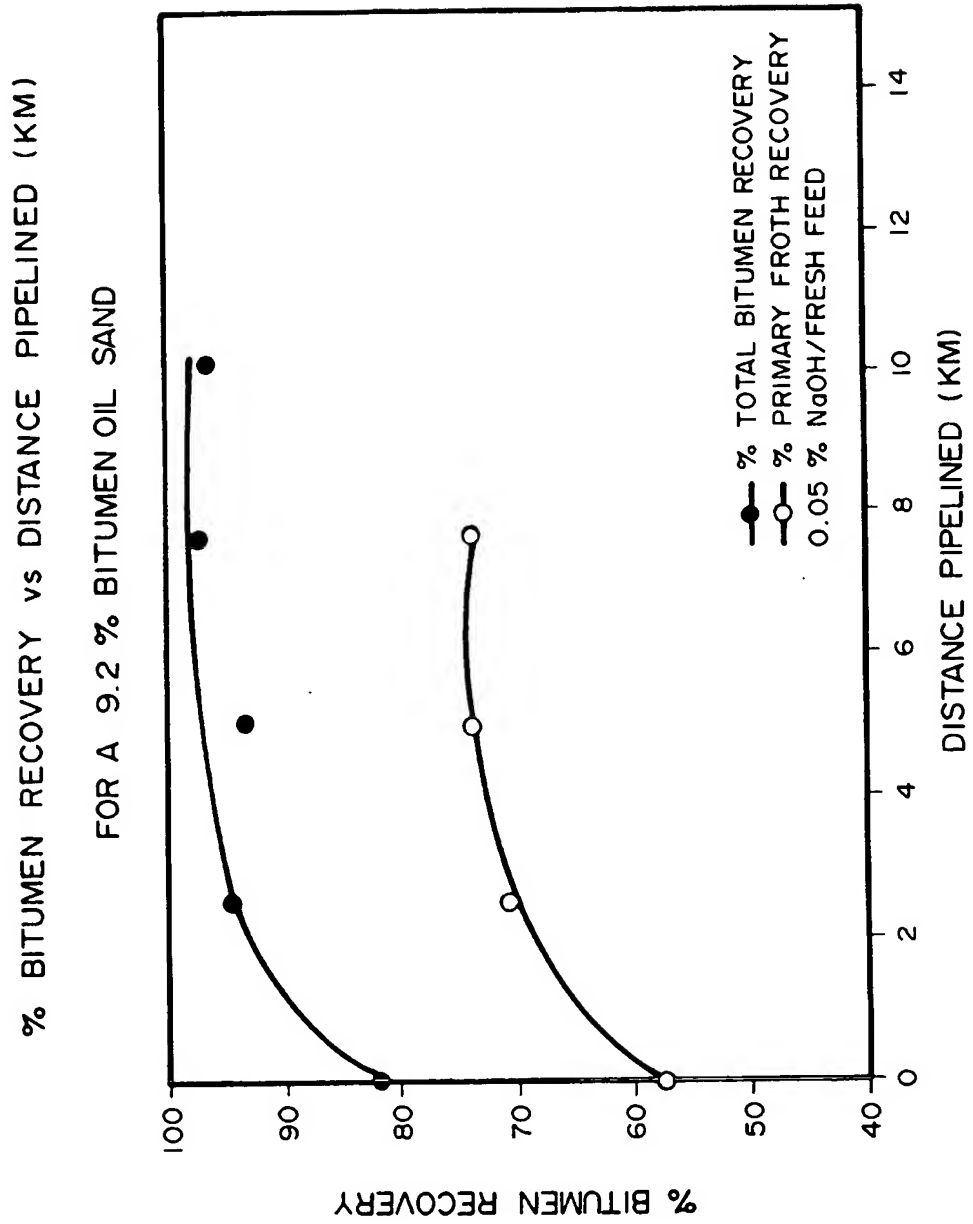
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Fig. 3.



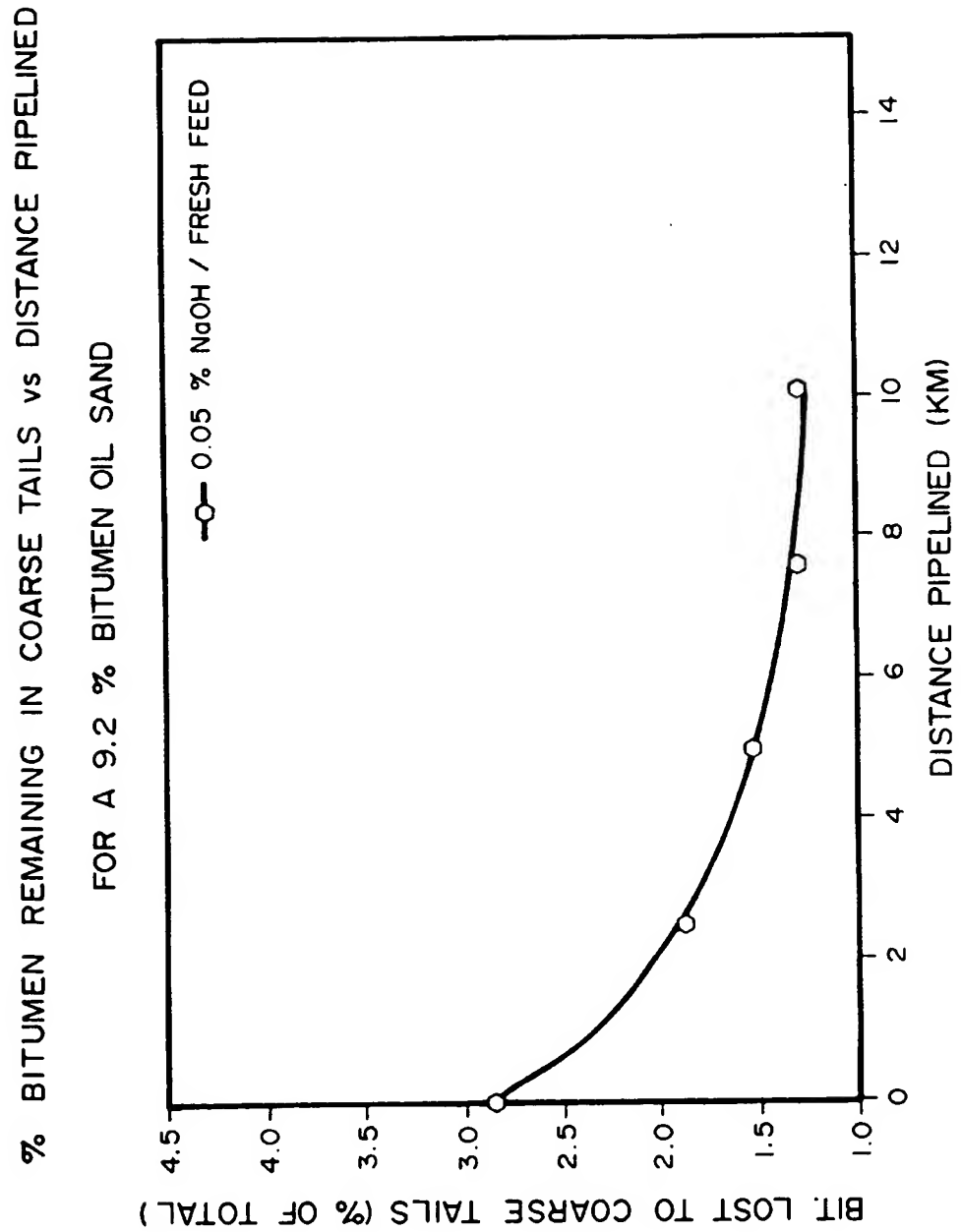
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Fig. 4.

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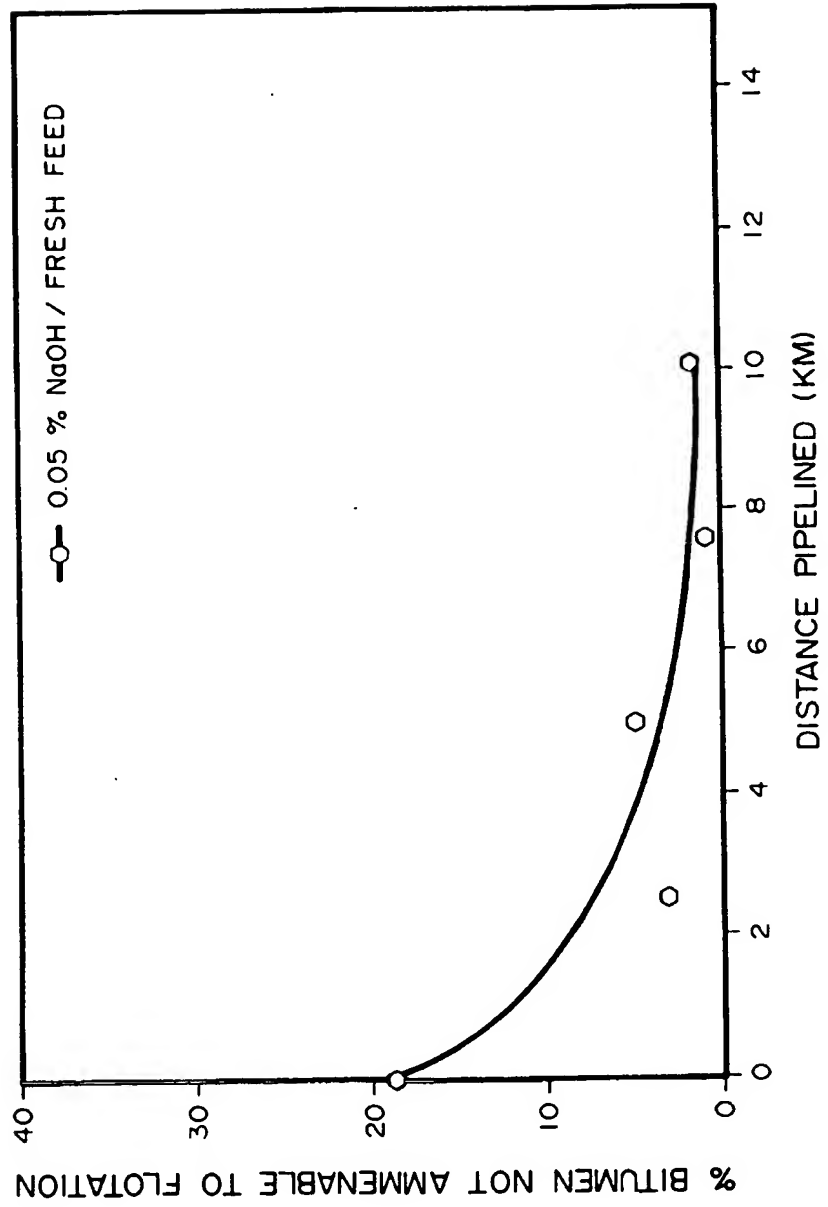
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Fig. 5.

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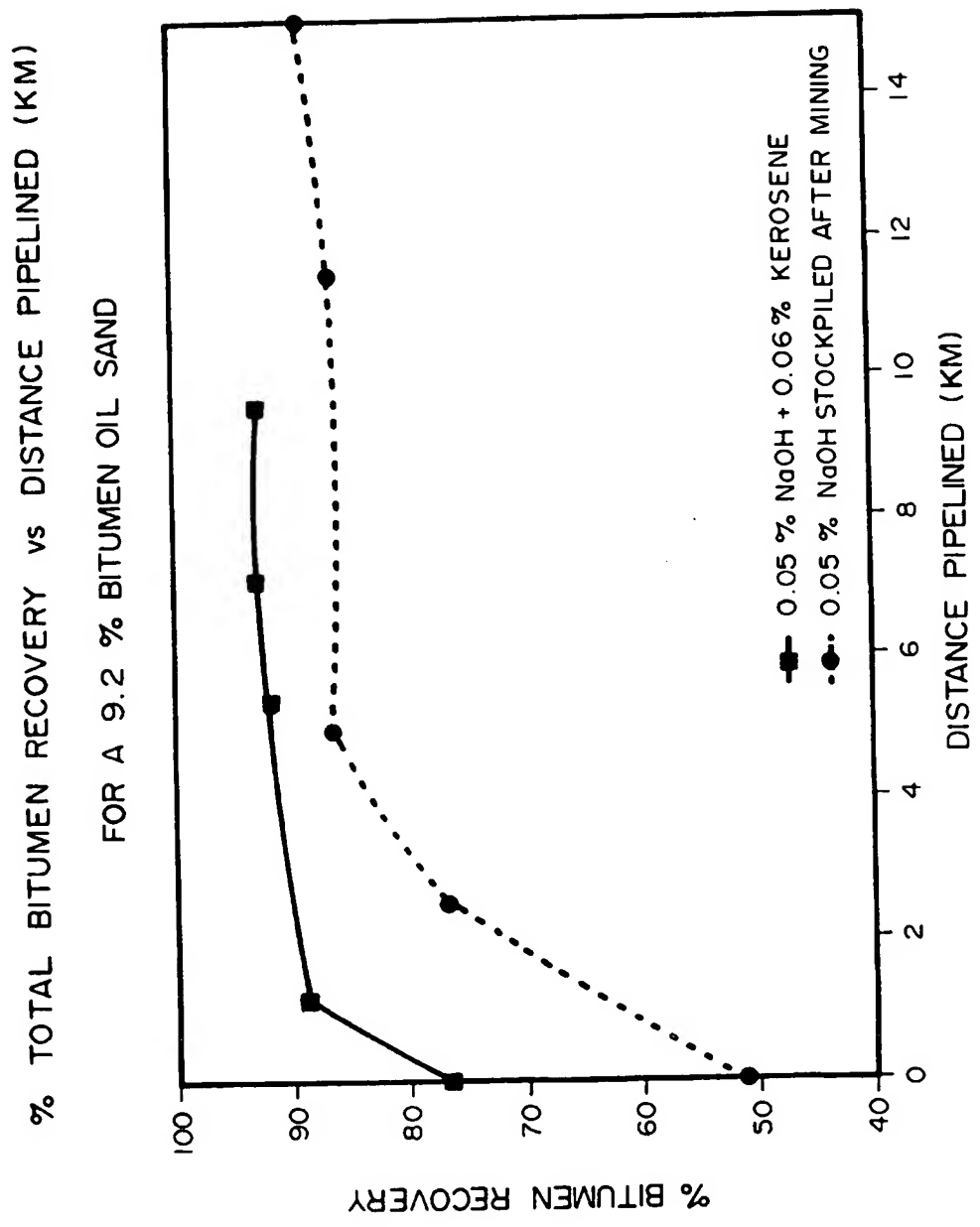
% BITUMEN NOT AMMENABLE TO FLOTATION vs DISTANCE PIPELINED  
FOR A 9.2 % BITUMEN OIL SAND



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Fig. 6.



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*E. P. Johnson*



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Patent agent:  
*E. P. Johnson*

